GOOD PRACTICE CASE STUDY 396

Cost-effective ventilation and cooling in new university buildings

– University of Lincolnshire and Humberside

- Mix of natural and mechanical ventilation
- Innovative desiccant cooling system
- Use of chilled beams, with 'free cooling' for much of the year
- 51% reduction in CO_2 emissions relative to traditional air-conditioned buildings

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BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

INTRODUCTION

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The Lincoln campus of the University of Lincolnshire and Humberside is one of the most recent university developments within the UK, with the first phase of the £18 million project being opened by Her Majesty the Queen in October 1996.

The first academic building at the site provides 10 000 m^2 of academic floor space with associated administrative and catering facilities. The second phase provides a Learning Resources Centre (LRC) of a similar size, with two professional-standard television studios.

Both buildings comprise a series of accommodation modules, each providing clear span floor plates and serviced by vertical cores containing stairs and plant risers. The modules are linked by high-level bridges and an internal thoroughfare.

The pre-cast structural buildings permitted fast-track construction and a quality finish. The potential for natural ventilation was carefully modelled to ensure a comfortable environment and achieve exceptionally low operating costs.

This Case Study outlines the radical design approach for the building services, with particular emphasis on the ventilation mix, chilled beams (with largely free cooling) and the adoption of a novel desiccant cooling system.

DESIGN APPROACH

The campus at Lincoln represents a major commitment to the future of the City. The University management were keen that this should be reflected by the design and construction of the first building. The architect was therefore encouraged to explore energy-efficient design solutions as a means of reducing the building's ongoing environmental impact and running costs. The architecture, structural and services proposals were integrated as a single strategy to maximise on energy efficiency.

The designs proposed were highly innovative, utilising chilled beams, with largely free cooling, and desiccant cooling. Although these may have been viewed as risky relative to traditional approaches, the University's confidence was subsequently vindicated by operating experience. The same design approach was used two years later for the LRC.

CONSTRUCTION AND BUILDING FABRIC

The Academic Building was constructed on reclaimed contaminated wasteland. The land clearing exercise involved the use of bio-piles, which were subsequently used for top soil.

The railway line immediately to the south dictated that this side of the building is sealed, while the north is more open to allow use of natural ventilation.

The U-values for the buildings on the campus are well within current Building Regulations (see table 1).

	U-value (W/m^2)
Walls	0.31
Floor	0.18
Roof	0.16
Glazing	1.90

Table 1 Showing U-values

HOST ORGANISATION

'Many see the use of conventional chillers as the obvious method of providing cooling. We believe, and have proved, that there are successful alternative solutions that can be used to lessen the environmental impact of a building and also reduce maintenance costs as well as running costs.

Our experience at Lincoln has confirmed this belief and demonstrated the wisdom of seeking high levels of energy efficiency wherever new buildings are being designed.'

Ian Grimwood, Project Services Engineer
Planning & Development Division
University of Lincolnshire and Humberside

CONCLUSIONS

Where cooling is required, this is generally provided by ceiling-mounted chilled beams that are fed with water at 14°C. For much of the year this cooled water is supplied simply by passing it through an external air blast cooler, but in the summer this is supplemented by a small conventional chiller. In this way, heat gains of up to 170 W/m^2 are accommodated and room temperatures of 24-25°C are maintained.

Heat gains in the television studios are much higher than this because of the requirement for specialist lighting and, consequently, these are the only areas where traditional air-handling units and a full-sized chiller have been provided.

Energy performance

The strategy of using low-energy cooling techniques wherever possible (and limiting the use of traditional chillers to serve only those areas where it is strictly necessary), has allowed the buildings to operate with very low energy use and associated costs.

This is illustrated by the LRC's energy performance relative to published benchmarks (HEFCE)[1] for air-conditioned libraries (see table 2).

CONCLUSIONS

New buildings provide a unique opportunity for innovative design solutions that are energy efficient and improve the learning environment. The University of Lincolnshire and Humberside has responded by providing buildings that are both cost-effective to construct (the LRC cost £946/m^2 excluding external works), and inexpensive to run. Such opportunities are open to all in the higher education sector whenever a new building is planned.

Table 2 A comparison of energy performance against published energy consumption benchmarks

Energy use	Lincoln Learning Resources Centre (kWh/m^2/yr)	Air-conditioned 'low' benchmark (kWh/m^2/yr)	Traditional 'low' benchmark (kWh/m^2/yr)
Electricity	118	292	46
Gas	145	173	115

VENTILATION

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The northern half of the Academic Building is largely open-plan and contains a student restaurant and offices. This cooler side of the building is constructed around a four-storey atrium that delivers stack-effect natural ventilation.

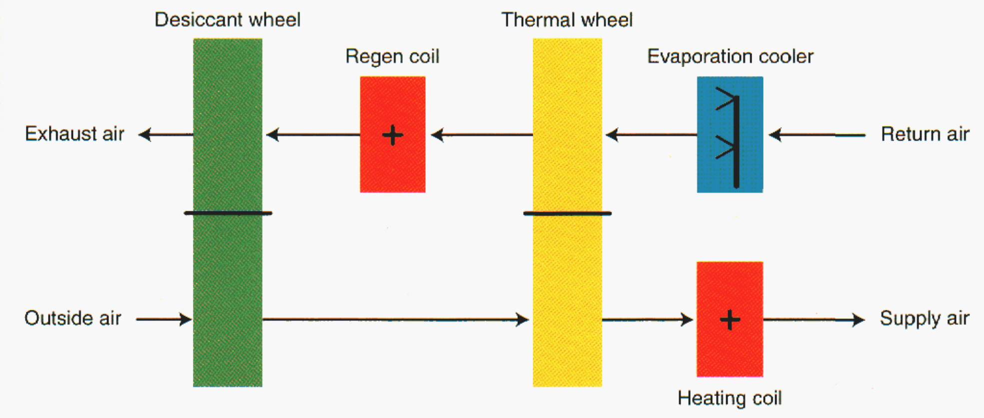
The southern half contains cellular teaching rooms that have significantly higher heat gains because of their higher occupancy and exposure to solar gains. These areas are mechanically ventilated. Fresh air is supplied by two central air-handling units with desiccant cooling plant to cool the supply air and remove its latent heat (moisture). This innovative approach (see box) is used to ventilate most of the LRC.

COOLING

The need for supplementary cooling is minimised by the use of:

- energy-efficient equipment, including high-frequency fluorescent lighting, which produces less heat
- exposed structural elements (eg ceiling soffits), which provide the thermal mass necessary to absorb transient heat gains during the day and moderate diurnal temperature fluctuations.

DESICCANT COOLING SYSTEM



Desiccant cooling can be used to condition the internal environment without the use of refrigerants. The process is driven by heat and is therefore ideal for sites that have combined heat and power or that dump waste heat.

Cooling is achieved by adiabatic evaporation of water within the air returning from the building. This in turn cools a thermal wheel that is then used to cool the supply air stream. Cooling performance is enhanced by using a desiccant wheel to dehumidify the incoming air, thereby reducing its latent heat load. At Lincoln the heat necessary to regenerate the desiccant wheel is provided by low-temperature hot water produced by gas-fired condensing boilers.

During the winter much of the required heat can be recovered from the thermal wheel, but a supplementary heating coil is available to enhance this.

FURTHER READING

REFERENCE

[1] Energy Management Study in the Higher Education Sector: Management Review Guide, Reference M16/96, Published May 1996, HEFCE

ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Energy Efficiency Best Practice programme publications are available from the BRECSU Enquiries Bureau. Contact details are given below.

Energy Consumption Guide

54 Energy efficiency in further and higher education – cost-effective low energy buildings

General Information Report

48 Passive refurbishment at the Open University. Achieving staff comfort through improved natural ventilation

Good Practice Guides

74 Briefing the design team for energy efficiency in new buildings

199 Energy efficient lighting – a guide for installers

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New Practice Case Studies

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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

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New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.